Renewable and Sustainable Energy Reviews 16 (2012) 2355–2360

Contents lists available at SciVerse ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Possibilities of application of waste wood biomass as an energy source in Vojvodina

Siniša N. Dodić[a,*], Tamara Zelenović Vasiljević[b], Radenko M. Marić[c], Aleksandar J. Radukin Kosanović[d], Jelena M. Dodić[a], Stevan D. Popov[a]

[a] Department of Biotechnology and Pharmaceutical Engineering, Faculty of Technology, University of Novi Sad, Bul. cara Lazara 1, 21000 Novi Sad, Vojvodina, Serbia
[b] JP Zavod za urbanizam Vojvodine, Železnička 6, 21000 Novi Sad, Vojvodina, Serbia
[c] Fakultet poslovne ekonomije, Univerzitet Edukons, Vojvode Putnika bb, Sremska Kamenica, Vojvodina, Serbia
[d] NVO "Kvantum", Filipa Višnjića 29, 21000 Novi Sad, Vojvodina, Serbia

ARTICLE INFO

Article history:
Received 7 June 2011
Accepted 30 January 2012
Available online 19 March 2012

Keywords:
Vojvodina
Waste wood biomass
Energy

ABSTRACT

The Autonomous Province of Vojvodina is an autonomous province in Serbia, containing about 27% of its total population according to the 2002 Census. It is located in the northern part of the country, in the Pannonian plain. Fruska Gora is a lonely island mountain in the Pannonian plain. The research presented in this paper highlights the potential of significant contributing to waste wood biomass in the Park "Fruska Gora (Vojvodina, Serbia) and points to the possibility of using biomass for briquettes production—the final product that can be used for energy purposes. The amount of woody biomass per hectare can be calculated if the data about the average number of trees per hectare are known. For the analyzed case, the value found in 1 ha was 383.1 m^3/ha or 272 ± 14 tons, and practically measured value was 402 m^3/ha, or 289 tons. The relative deviation of calculated and obtained values of Canadian poplar wood biomass per hectare was 5.88%. Quantities of planned wood waste biomass can be used to produce high-quality briquettes for thermal energy generation purposes in the equivalent of 4.8 million kWh. The large energy potentials, in Vojvodina are still substantially unused, and besides of using waste wood from forestry, it is necessary to consider the sustainable use of available waste biomass from the timber industry.

Contents

1. Introduction

With industrialization of society, the energy needs are growing steadily. Given that the depots of non-renewable energy sources, primarily fossil fuels are limited and significantly exploited, the use of renewable energy sources is the only viable solution of energy problems of modern industrial society.

The Autonomous Province of Vojvodina is an autonomous province in Serbia, containing about 27% of its total population according to the 2002 Census. It is located in the northern part of the country, in the Pannonian plain. In Vojvodina, evident is the problem of energy dependence with respect that the amounts of conventional energy sources are limited, but it is estimated that the energy potential of renewable energy sources, mainly biomass, is significant. Economy, especially agriculture and forestry represent significant consumers of energy, but also very important potential energy producers [1–3].

* Corresponding author.
E-mail address: dod@uns.ac.rs (S.N. Dodić).

1364-0321/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
doi:10.1016/j.rser.2012.01.079

It is estimated that the total annual potential of renewable energy sources in Serbia is equal to almost half of the annual the country's needs for energy. Using renewable energy sources contributes to the development of industry i.e. the implementation of new technologies and increase of employment [4–8].

Fruska Gora is lonely island mountain in the Pannonian plain. To the south and the north it is very much diversified with mountainous and river courses, with a narrow main ridge from which protrude individual, lateral ridges, most often with very steep slopes. Location, specific geological history, different microclimatic conditions make this mountain to be very interesting and important for various scientific fields. Thanks to the unique and very rich fossil fauna and flora, Fruska Gora is called "the mirror of geological history". Flora of Fruska Gora is very specific and characterized by great diversity. At the National Park there are about 1000 species of plants, while with the plants in the area of protection zone, recorded are about 1500 species [9].

Researches presented in this paper highlight the potential of significant contribution of waste wood biomass in the National park "Fruska Gora" (Vojvodina, Serbia) and indicate the possibility of using of waste biomass for briquettes production—the final product that can be used for energy purposes.

Trend of growth of renewable sources of energy Vojvodina in the last few years, is increasing one, thanks to a series of legislative and economic measures that allow increasing of share of renewable energy sources. With introduction of "feed-in" tariffs, renewable energy sources are becoming more profitable and affordable in all spheres of human activities.

Analysis of availability of resources of waste wood biomass in the National Park "Fruska Gora", that could be used for the production of the high quality firing briquettes in service of the environment protection, is intended to [10]:

- promote the use of wood biomass for thermoenergetic purposes,
- highlight the positive impact of collecting of waste wood biomass on the environment,
- establish positive socio-economic impacts and refer to the possibility of market development of the high quality firing briquettes in Vojvodina,
- perform the identification of players which may be involved in the implementation process of collecting of waste wood biomass.

These researches have positive impact and significant role in raising environmental awareness, and provide a comprehensive assessment of options for the plant for the production of high quality firing briquettes from waste wood biomass.

2. Renewable sources of energy

Renewable energy sources are sources that may be found in nature and that have the ability of renewing, in whole or in part by using of effective and environmentally friendly natural or artificially induced processes [11].

Renewable energy sources are classified in several basic groups:

- biomass – biogas/methane, pellets and briquettes, biofuels (biodiesel – I, II and III generation, bioethanol – I and II generation, biomethanol, helio-agriculture, biobutane, biopropane and biohydrogen),
- geothermal energy,
- energy of water (hydro potential),
- wind energy,
- sun (photovoltaic) energy.

3. The concept and definition of biomass

Biomass is the organic matter of vegetable or animal origin and is one of the sources of renewable energy that is used in combustion processes or converted in systems for the production of energy (heat and electricity).

According to the EU Directive 2003/30/EC, biomass is biodegradable fraction of products, wastes and residues from agriculture (including plant and animal substances), forestry and the wood processing industries as well as the biodegradable fraction of municipal and industrial wastes which is permitted for use in energetics, in accordance with relevant regulations for the environment protection.

Biomass occurs in nature or as a byproduct of human activities in a number of forms, some of which are:

- plant origin wastes from agriculture and forestry, plant origin wastes from the food industry (for the heat production)
- fibrous vegetable wastes from pulp and paper production (for heat generation by co-incineration)
- wastes originating the wood processing industry (excluding wood waste which may contain halogenated organic compounds or heavy metals originating from the wood preservatives).
- Biomass appears in: solid (briquetted biomass), liquid (biodiesel, bioethanol, biomethanol) and gaseous physical state (e.g. biogas, landfill gas).

Biomass of plant origin is a product of photosynthesis in plant organisms. Biomass of animal origin is produced as a product – the rest is in the process of feeding of animals. Thus explained concept is very wide, but the basic concept is that the biomass is consumed and renewed continuously, in the cycle of circulation of material and energy in the nature. Man, with his activities, increases the amount of biomass that is circulating in the environment.

Biomass consists of products of plant and animal origin (unused parts from the wood-processing industries, agricultural production, food processing, of municipal waste of organic origin and the like).

In agriculture remains a large amount of unused biomass. Also, in crop production process remain significant amounts of wastes: the remains of the pruning of fruit trees, vines and olive trees, straw, cornstalks, sunflower stalks, etc. [12].

With carefully planned procedures of management with forest potentials, increased yields of biomass that can be achieved in the region of forestry i.e. the rest of the biomass that comes from wood-processing industry. Vojvodina, which is predominantly agricultural region, has a great potential of using biomass originating from agriculture, forestry and wood processing industry [13].

Technically exploitable annual energy potential of biomass in the Republic of Serbia is about 2.7 Mtoe. The energy potential of biomass from forestry and wood industry (cutting of trees and the remains of trees produced in the primary and/or industrial processing of wood) is estimated to be approximately 1.0 Mtoe, while about 1.7 Mtoe originates from agricultural biomass (agricultural wastes and residues from farming, including liquid manure). Biomass has traditionally been used for heat generation and it was estimated on 0.3 Mtoe in the year 2008, being equivalent to the energy of natural gas valued at 637 million US$.

Most promising options for using biomass in Vojvodina are:

- heating of housing units and industrial plants using pellets or briquettes produced from biomass,
- co-combustion or complete replacement of the firing of fuel oil or coal in the heating plants,

- production of electricity using agricultural and wood processing residues and
- production of biofuels.

4. EU standards for briquettes and pellets

In order of rational manipulation of biomass as a source of renewable energy, in terms of reducing its volume, briquetting and pelleting are performed.

Because of tendencies in the European Union for the use of renewable energy sources, it was necessary to define a set of standards to facilitate packaging and handling of final products from biomass by the end users (primarily households and industry).

In March 2004 Standard of the European Commission ptCEN/TS-14961: 2004, which defines categories of pellets according to their origin (remains of agriculture or wood waste) and according to the use for thermal energy generation purposes has been accepted. Although the Standard ptCEN/TS-14961: 2004 does not apply to briquettes and briquetting process, it clearly stipulates the maximum shares of some chemical elements in the structure of biomass, and therefore the quality of briquettes [14]. In this way, control of chemical structure of biomass, or briquettes and pellets affects the satisfaction of the prescribed emission limit values of pollutants that are released during the combustion.

Comparing data about GVE from regulation on emission limit values of pollutants into air concerning the emissions of harmful gases into the atmosphere during the combustion wood and wood materials for boilers with power of 10–50 MW, and values defined in Standard ptCEN/TS 14961: 2004 of European Commission, it is evident that the values according to the regulation are considerably higher [15].

Also, the Standard of European Commission defines the GVEs for a significantly larger number of chemical elements whose compounds can have a negative impact on the environment and human health (Fig. 1). Further harmonization of national legislation with the EU legislative will open up new possibilities for the market development for briquettes and pellets from wood biomass in Serbia and for more significant distribution of these products to the European Union countries.

5. Thermo-energetic properties of biomass in the National Park "Fruska Gora"

The basic thermo-energetic characteristics of wood biomass are: calorific value, the content of volatile organic compounds, the amount and the composition of ash, density, wood moisture, and so on. The value of timber as energent can be adequately evaluated if it is possible to calculate its upper calorific value [16].

The upper calorific value of wood, is realized when the wood is in absolutely dry state and it is different in different species of wood [17]. These differences are correlated with the shares of basic components and the extractive substances in the wood structure. Wood in the absolutely dry state is composed of carbon, hydrogen and oxygen. In addition to these basic elements, composition of the wood includes small percentages of nitrogen, sulfur and trace elements, which are the basic ingredients of ash after the combustion of wood. The elementary chemical composition of wood depends on: type of wood, age of wood and the part of wood from which is the sample taken. The actual energetic effects, which would be obtained by burning, are always lower than its energy potential or the upper calorific value.

Heat potential of wood directly depends on its moisture content, which is the most important factor in the investigation of biomass combustion.

Wood wastes have:

- external moisture, if the waste wood was lying in water, or has been poured over with water, or if it was affected by snow or ice. This moisture is removed by thawing and straining;
- intrinsic moisture, where we distinguish between the water of cells lumen and vessels – the so-called free water, and hygroscopic water bounded with cell walls – the so-called bound water. Intrinsic moisture is removed by natural or industrial biomass drying in its processing in order to obtain the briquettes.

Both types of drying have their advantages and disadvantages. Basic limitations of the natural drying are long time for drying and uneven drying, and in industrial drying disadvantage is great energy consumption. When studying the quality of wood mass, it is common to calculate the relative share of wood moisture in relation to the absolutely dry substance.

Wood increased humidity has lower calorific value and less efficient combustion. Humidity during combustion is useless ingredient that further reduces the calorific value of wood. Of the heat released by burning of wood is used for moisture evaporation and superheating the water vapor to a temperature in the furnace. In the furnace of boiler is spent about 2500 kJ/kg for the evaporation of water and somewhat smaller amount heat for its overheating. On this amount of released water should be added the water resulting from combustion of hydrogen from fuel. Also, on the total amount of energy required for processing of biomass, it is necessary to add the energy required for drying of wood [18,19] (Table 1).

Volatile compounds in wood are mainly light hydrocarbons. Mass participation of volatiles in the wood is determined by measuring the solid residue after heating the sample of wood for 7 min in a stove, at the temperature of 900 °C and without the presence of oxygen. Average volatiles mass participation in domestic species of wood is about 75%, coke residue is 15–20%, and ash content is up to 0.6%. The above values are different for different types of trees and the tree parts from which the sample was taken. The most common elements that remain after the combustion of wood in the form of ash are potassium, sodium, magnesium, which make up 0.5–4% of the wood mass. Because that the largest part of harvested wood biomass the National Park "Fruska Gora" is obtained by collection of fallen branches and old and diseased trees (which contain more minerals than the bare round timber) it can be expected that the obtained biomass would have an increased percentage of mineral substances.

Woody biomass collected from the National Park "Fruska Gora" has in relation to the quality lower values compared with the quality of wood biomass that can be collected from the primary wood industry and the sawmills. However, woody biomass collected in the territory of National Park "Fruska Gora" can be effectively utilized for production of the high-quality briquettes that would meet the standards set in the ptCEN/TS-14961 (Table 2).

Mass coefficients and the relative densities are data that are given for wood biomass containing about 20% of moisture. With reduction of the level of moisture, reduces the relative density and the calorific value (lower calorific value MJ/kg) increases. If it is regarded the application of wood biomass in the production of briquettes, wood biomass, which is processed and briquetted gives much better results during the combustion. Usually, the biomass is industrially dried to 12% of moisture, when applied in the production of briquettes. Generally, soft trees are easy and they burn easily and relatively quickly, with the high temperature fire, and with a tendency to throw sparks. Hardwood trees, according to the characteristics of combustion are such that they hardly begin to burn, but after that the burning is longer and uniformly distributed over the surface of wood. Cut wood contains a very high moisture content; sometimes more than 60% by weight of wood is water, and it is therefore necessary to solve the technical process of drying of wood in terms of adjustment of biomass prior to the briquetting process.

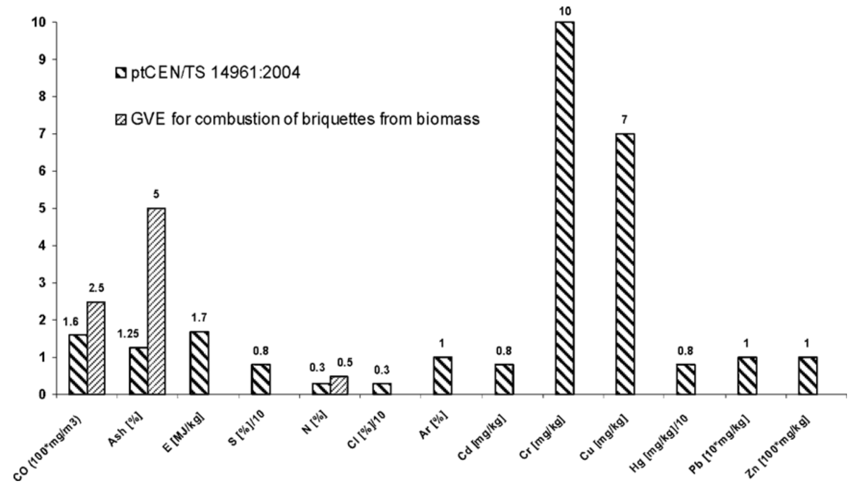


Fig. 1. Comparative overview of pollutants according to the ptCEN/TS 14961: and the regulation on limit values for emissions of pollutants into the air.

Table 1
Typical values of useful heat, depending on the proportion of moisture content in the combusted wood biomass.

Moisture content (%)	Upper calorific value (MJ/kg)	Degree of efficiency of furnace (%)	Useful heat (MJ/kg)
0	19.8	80	15.8
10	17.8	78	13.9
40	14.5	74	12.1
70	12	72	8.6

This is usually accomplished using "rotating drum" dryers or by the use of dryers which at the same time perform comminution and drying—a dynamic method of drying of biomass.

6. Analysis of the available amount of waste wood biomass in the National Park "Fruska Gora"

Assessment of the available amount of waste wood biomass results in obtaining of data that depend on the provisions of laws and regulations relating the rational use of wood waste biomass created in the process of restoration of forest fund on the management units that are managed by Public Enterprise "Fruska Gora National Park". Provisions governing the manner and amount of available wood waste wood biomass determine the Provincial Institute for Nature Protection.

Convention on Biological Diversity points to the need of regulation or management of biological resources that are important for the conservation of biological diversity, within and outside of protected areas and with aim of their conservation and sustainable utilization.

Conditions of the Provincial Bureau of environmental protection, stipulates that the collection of wood waste resources in National park can be done only in the territory of a particular regime with II and III degree of protection under the following conditions:

(1) Given that a large number of endangered and strictly protected species of insects (wasp-like flies and other species) the development of which is specifically related to fallen wood mass it is necessary to leave 10% of timber volume by wood assortments, what refers to the rotten tree trunks and dead bodies, the thin and the thick tree branches;
(2) The average timber volume intended for leaving in the percentage specified in the item above, do not move from place on which it was left after harvest, close to where there are stumps, or where the cut or fallen trees have grown;
(3) Priority when leaving the felled timber on site give to dry, rotten and hollow parts, because of the fact that these are habitats for larval shape of endangered species of insects, fungi and other users of organic substances;
(4) The forest stands in which the planned forest-breeding measures specified filling of sessile oak (opening of oak trees in the order to form a crown for reproduction in the following period), i.e. the reconstitution of oak forests, what is in accordance with the protection measures prescribed by 2022, the volume of all

Table 2
Data on material properties of different types of wood, mode of their combustion and their calorific values at combustion of biomass with moisture content of 20%.

Wood species	Relative heat content	Easiness of combustion	Easiness of breaking into pieces	Presence of smoke	Sparks appearance	Aroma at combustion	Lower calorific value (MJ/kg)	Density (kg/m^3)	Rating
Ash tree	High	Yes	Yes	Not	Not	Minimal	13.11	670	Excellent
Oak	High	Yes	Not	Not	Not	Partially	14.28	590–930	Excellent
Beech	High	Yes	Yes	Not	Not	Minimal	14.11	680–720	Excellent
Maple	High	Yes	Not	Not	Not	Not	14.17	755	Excellent
Elm	Medium	Medium	Not	Medium	Not	Medium	14.13	690	Medium
Linden	Low	Yes	Yes	Medium	Not	Not	14.2	560	Medium
Acacia	High	Weak	Not	Not	Not	Minimal	15.22	520–733	Good
Hornbeam	High	Not	Not	Not	Not	Not	14.14	/	Excellent
Poplar	Nisko	Yes	Yes	Medium	Not	Not	13.73	710	Medium

Table 3
Yields of wood and of waste wood biomass on stands for which is in 2011 planned the reconstruction.

Wood species	Location	Area planned for reconstruction (ha)	The yield of woody biomass (m^3)	The yield of waste wood biomass (m^3)	Waste wood biomass (m^3/ha)
Poplar	Susek	32.59	13,100	1965	60.3
Acacia	Erdevik	~1.5	625	50	32.3
Acacia	Erdevik	~1.8	750	60	33.3

Table 4
Data on the quantity of briquettes and their energetic values.

Waste wood biomass (m^3)	Kind of wood	Wood biomass density (kg/m^3)	Losses of wood biomass in the production of briquettes (%)	Quantity of the obtained briquettes (tons)	Energetic value of the obtained briquettes (MJ)
1965	Poplar	710	23	1100	17.3×10^6

felled oak should be left in the sections in which these measures are conducted;

(5) In the forest stands in which is planned to remove the over-mature acacia trees as an allochthonous, invasive species, all harvested volume of acacia should be removed from the stand, or the part of timber can be used for respective needs, in the accordance with the terms of controlling measures postulated by management of the National Park;
(6) Other types of trees felled such as linden, hornbeam, ash tree and other softwood can be used in the accordance with the specified measures;
(7) Prohibited is any construction or reconstruction of the access roads for project implementation;
(8) For the purposes of in the collection process approved timber, one has to use the existing logging roads using the light machinery, under conditions to be obtained from the controlling management;
(9) For works which are not specified in the request, and that may be necessary, the investor has to obtain new conditions from the Provincial Institute for Nature Protection.

Based on these conditions, an analysis of the available amounts of waste wood biomass on the territory of National Park "Fruska Gora" was performed. Measurement of quantities of waste wood biomass was performed in the management units in the vicinity of Susek and the surroundings of Erdevik.

Parts of the management units are designated for renewal in the next year and the analysis of representative samples of waste wood biomass of trees in the sections planned for reconstruction, and the project these samples served for the calculation of waste wood biomass.

Of the utmost importance is the information about planned felling on stands of management unit in the vicinity of Susek. For the year 2011 planned is the reconstruction of artificially established stands of Canadian poplar with average age of 27 years, which are formed in the parts of sections five and eight [20].

For stands of the type Canadian poplar optimal age is 25 years and after the expiration of this period it is advisable to carry out the reconstruction of the stand, which includes clean cutting of planned areas. The total area for which is in the next year planned the restoration of Canadian poplar, and thus the clean cut is 32.59 ha, where the expected volume of total wood biomass yield amounts to 13,100 m^3 (402 m^3/ha).

From the specified total amount of woody biomass, according to the conditions provided by the Provincial Bureau for Environmental Protection, it is possible some 15% to classify as the waste wood biomass, what amounts to 1965 m^3. The mean value of the waste biomass is 60.3 m^3 of waste wood biomass per 1 ha.

Analysis of the waste woody biomass of Canadian poplar (location Susek) is obtained when felling stands with Canadian poplar. For reasons of natural balance of flora and fauna, 10% wood waste biomass is necessary to leave in the forest. Volume of waste biomass available is 1965 m^3 (Table 3). Based on this information it is possible to calculate the amount of briquettes that can be obtained from these waste wood biomass, as well as an orienting energetic value of the underlying briquettes. Table 4 shows the data on the quantity of briquettes and their energetic values.

Based on the data on the mean thickness of trees measured at a height of 1.3 m above the ground (chest thickness of the tree), it is possible to calculate the energetic value for the amount of biomass per tree, which is 1360 ± 70 kg. In the area at which the reconstruction of Canadian poplar is performed, which have age of 27 years, with mean thickness of tree being 47.5 cm, the average number of trees per 1 ha has about 200.

It must be noted that data on the number of trees per hectare vary widely, depending on numerous factors relating to formation of stands. The amount of woody biomass per hectare can be calculated if the data on average number of trees per hectare are known. For the analyzed case, the value found in 1 ha was 383.1 m^3/ha or 272 ± 14 tons, and practically measured value was 402 m^3/ha, or 289 tons. The relative deviation of calculated and obtained values of Canadian poplar wood biomass per hectare was 5.88%.

7. Conclusion

Forest regeneration plan in the National Park "Fruska Gora" (Vojvodina, Serbia), area of approximately 32 ha of artificially established stands of Canadian poplar, gives the relatively large amount of waste wood biomass per hectare.

Quantities of planned wood waste biomass can be used for the production of high-quality briquettes for thermoenergetic purposes in the equivalent of 4.8 million kWh. In the other Management units within the National Park "Fruska Gora" the theoretical values of wood waste are much higher, but its use is limited by legal requirements and field conditions.

It is also necessary to note that in addition to waste wood that remains after the cutting of forests, an important source of raw materials are industrial wood processing plants. Wastes from wood processing are a significant problem in the industry because of its storage and fire hazards, if its further use is not organized.

Therefore, because of the large energy potential, in Vojvodina still substantially unused, except the possibility of using waste

wood from forestry, it is necessary to consider the sustainable use of available waste biomass from the wood processing industry.

Acknowledgments

This work was financed by the Ministry of Education and Science, Government of The Republic of Serbia and Provincial Secretariat for Science and Technological Development of AP Vojvodina.

References

[1] Dodić S, Popov S, Dodić J, Ranković J, Zavargo Z. Potential contribution of bioethanol fuel to the transport sector in Vojvodina. Renew Sust Energy Rev 2009;13:2197–200.
[2] Dodić S, Popov S, Dodić J, Ranković J, Zavargo Z. Potential development of bioethanol production in Vojvodina. Renew Sust Energy Rev 2009;13: 2722–7.
[3] Dodić S, Popov S, Dodić J, Ranković J, Zavargo Z, Golušin M. An overview of biomass energy utilization in Vojvodina. Renew Sust Energy Rev 2010;14:550–3.
[4] Dodić S, Popov S, Dodić J, Ranković J, Zavargo Z, Jevtić-Mučibabić R. Bioethanol production from thick juice as intermediate of sugar beet processing. Biomass Bioenergy 2009;33:822–7.
[5] Munitlak-Ivanović O, Golušin M, Dodić S, Dodić J. Perspectives of sustainable development in southeastern European countries. Renew Sust Energy Rev 2009;13:2079–87.
[6] Dodić S, Popov S, Dodić J, Ranković J, Zavargo Z. Biomass energy in Vojvodina: market conditions, environment and food security. Renew Sust Energy Rev 2010;14:862–7.
[7] Dodić S, Vučurović D, Popov S, Dodić J, Zavargo Z. Concept of cleaner production in Vojvodina. Renew Sust Energy Rev 2010;14:1629–34.
[8] Dodić S, Vučurović D, Popov S, Dodić J, Ranković J. Cleaner bioprocesses for promoting zero-emission biofuels production in Vojvodina. Renew Sust Energy Rev 2010;14:3242–6.
[9] Stevanović V, Blaženčić J, Vasić V. Biodiverzitet Jugoslavije sa pregledom vrsta od međunarodnog značaja. Beograd: Biološki fakultet; 1995.
[10] Stojkov A. Studija opravdanosti korišćenja drvnog otpada u Srbiji. Beograd: Energy Saving Group, USAID; 2009.
[11] Ilić M, Grubor B, Tešić M. The state of biomass energy in Serbia. J Thermal Sci 2004;8(2):5–19.
[12] Tešić M, Babić M, Martinov M. Predstojeći podsticaji za korišćenje biomase kao energenta. Novi Sad: Savremena poljoprivredna tehnka; 2007.
[13] Zekić V, Tica N. Ekonomska opravdanost korišćenja žetvenih ostataka kao izvora energije. Novi Sad: Faculty of Agriculture; 2010.
[14] Alakangas E. New European Pellets Standard-EN 14961-1. EUBioNet 3, Finska, 2007.
[15] IEA Bioenergy. Global wood pellets markets and industry: policy drivers, market status and raw material potential. Task 40, 2007.
[16] Bridgwater A, Toft A, Brammer J. A techno-economic comparison of power production by biomass fast pyrolysis with gasification and combustion. Renew Sust Energy Rev 2002;6:181–246.
[17] Brkić M, Tešić M, Furman T, Martinov M, Janić T. Potencijali i mogućnosti briketiranja i peletiranje otpadne biomase na teritoriji pokrajine Vojvodine. Novi Sad: Poljoprivredni fakultet, Fakultet tehničkih nauka; 2007.
[18] Dodić S, Zekić V, Rodić V, Tica N, Dodić J, Popov S. Analysis of energetic exploatation of straw in Vojvodina. Renew Sust Energy Rev 2010;15:1147–51.
[19] Dodić S, Zekić V, Rodić V, Tica N, Dodić J, Popov S. Situation and perspectives of waste biomass application as energy source in Serbia. Renew Sust Energy Rev 2010;14:3171–7.
[20] Ministarstvo rudarstva i energetike Republike Srbije, Energetski bilans Republike Srbija za, 2006.